Outdoor Comfort Report: Weston Site

Existing Condition

This report assesses and evaluates the existing site in Weston, Toronto, ON for current outdoor comfort conditions. The report is based on City of Toronto Outdoor Thermal Comfort Guidelines and references city outdoor comfort targets for design and development.

The report consists of two sections:

Section I: Wind Analysis and Pedestrian Level Comfort
wind analysis, pedestrian level wind comfort, high-level UTCI scenarios

Section II: Detailed UTCI
UTCI maps, wind and direct radiation map

newyork@transsolar.com
220 E 23rd St. Suite 403
New York, NY 10010
KP VZ
+1 212 219 2255

Existing Outdoor Comfort Conditions – Weston Site (Section I)

Wind Analysis and Pedestrian Level Comfort

This section presents an overview of current outdoor comfort conditions at the Weston site, focusing on the two dominant factors: **wind** and **solar exposure**. These analyses form the basis for the detailed Universal Thermal Comfort Index (UTCI) maps (section II), which consolidates multiple comfort drivers into a single value for each 10 m grid of the site.

Section I includes:

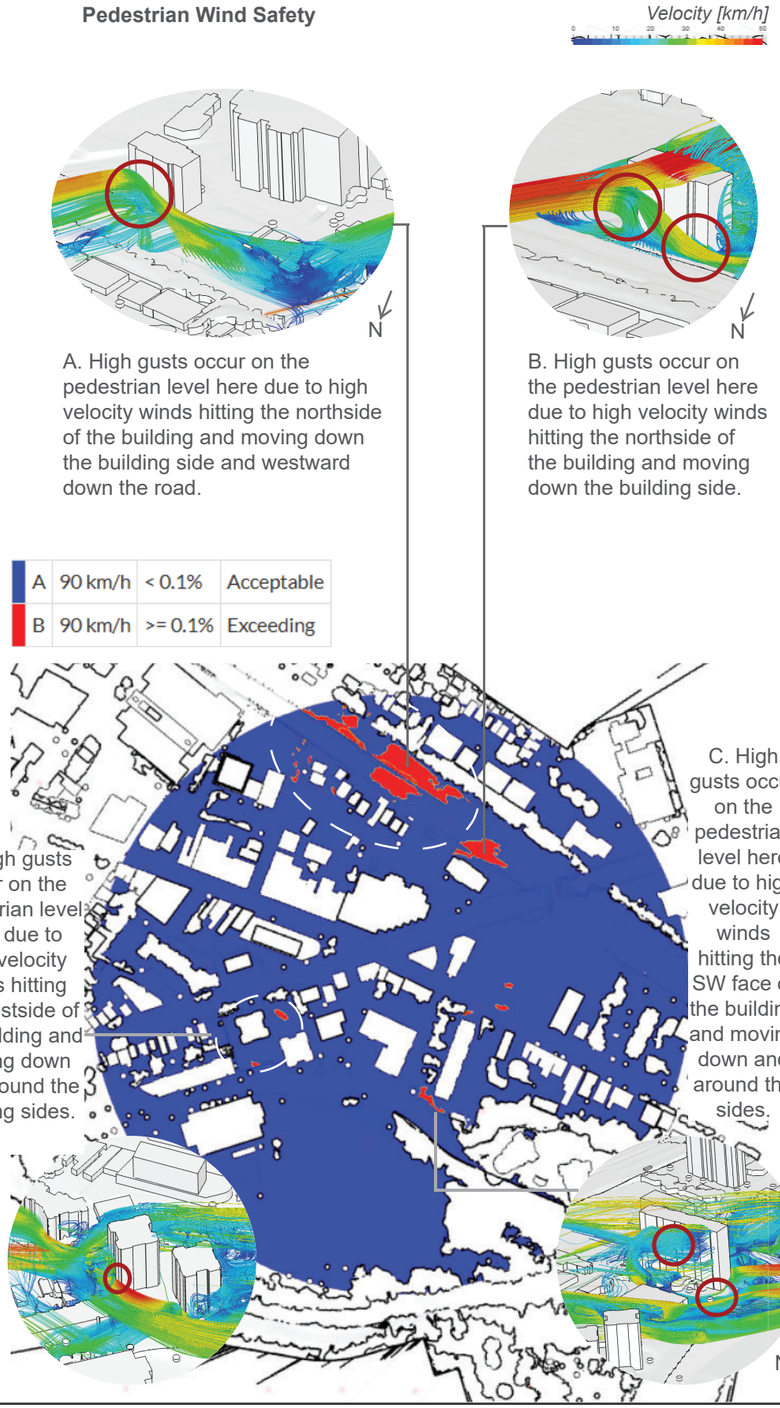
- **Wind:** Computational fluid dynamics (CFD) simulations were conducted for 16 wind directions to understand seasonal patterns and magnitudes affecting pedestrian comfort. A **pedestrian wind comfort study** was also completed, assessing the *mechanical comfort* of wind for pedestrians.
- **Solar:** A representative solar radiation study was completed to assess the shading effects of typical buildings in the area.
- **Combined comfort**: A preliminary comparison was made between expected UTCI results and varying combinations of wind, solar, air temperature, and humidity across the seasons.

While the detailed UTCI maps in Section II provide a high-resolution, site-specific view of comfort conditions, the reduction of all variables to a single number can obscure *the causes* of comfort or discomfort. This section therefore highlights the key driving forces—wind exposure and solar access—so they can be explicitly considered in decision-making.

Executive Summary

- Existing site wind comfort and safety assessed according to Toronto Wind Comfort and Safety Criteria. There are key regions where gusts result in unsafe conditions. These gusts are created from downdraft and wind redirection from tall buildings, which are highlighted.
  - Stategies like base buildings/podiums, increased vegetation and wind barriers can reduce these gust scenarios and reduce unsafe conditions.
  - Development upwind can also reduce these unsafe zones.
- Pedestrian wind comfort is within comfortable ranges for all seasons except winter in which there are a few small regions of uncomfortable areas at the northwest end of the site near the train tracks.
  - Further strategies can be implemented to move between wind comfort categories according to the desired usage for that location.
  - In this climate, calm (low wind) conditions are largely favorable year-round to increasing thermal comfort, but has a counter impact of being air stagnant areas. There are low air circulation areas particularly between dense buildings. Further decision-making on local design intent and use will inform their prioritization.
- While wind is the main driver of thermal comfort in this climate, solar access is another key factor determining the overall thermal comfort. A section at the center of the area of study was studied per season, evaluating its solar radiation levels.
  - Winter can be up to 53-82% comfortable through wind reducing measures. Increasing sun access achieves the upper end of this range.
  - Summer is largely comfortable, but can be improved to 96% comfort.
  - Shoulder seasons have the greatest potential for extending the comfort period; comfort can be increased by more than 30%.

Pedestrian Wind Safety



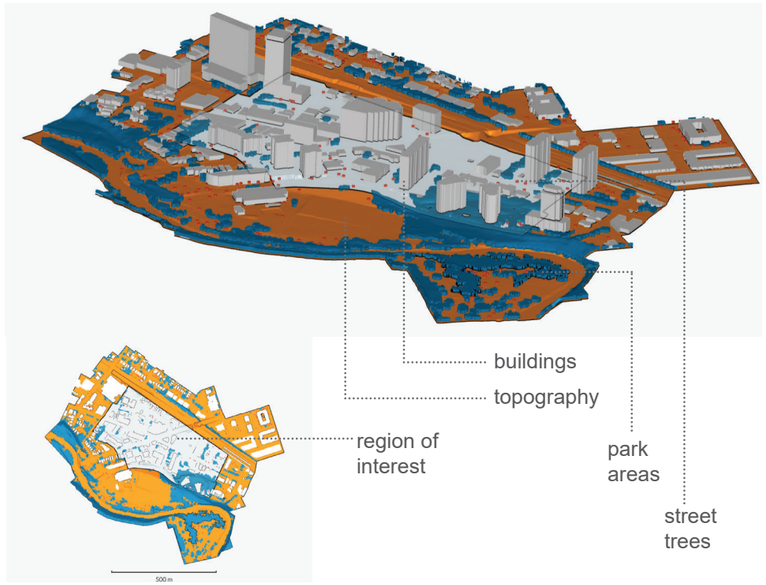


Figure 1: Model of Existing Scenario
(light blue is simulated region of interest)

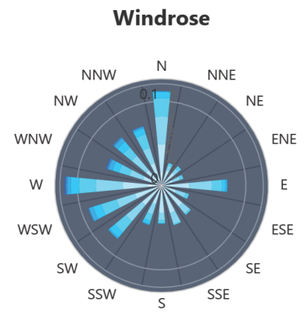


Figure 2a: Annual Wind Rose
00:00 - 00:00

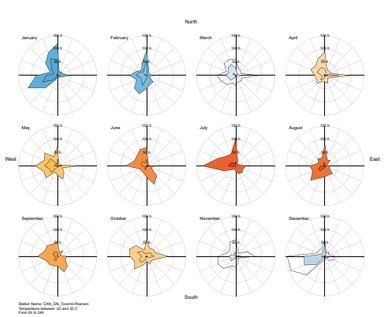


Figure 2b: Monthly Wind Rose
00:00 -00:00

Safety Category	Gust Speed [km/h]	Minimum Occurence [% of time]	Description	Area of Application
Exceeded	> 90	0.1	Excessive gust speeds that can adversely affect safety and a pedestrian's balance and footing. Wind mitigation is typically required.	Not acceptable in any areas of interest.

Figure 3: City of Toronto Pedestrian Wind Safety Criteria

newyork@transsolar.com
220 E 23rd St. Suite 403
New York, NY 10010
KP VZ
+1 212 219 2255

Existing Outdoor Comfort Conditions – Weston Site (Section I)

Wind Analysis and Pedestrian Level Comfort

The pedestrian wind comfort is assessed cumulating the 16 wind directions from historical weather file data for velocity, direction, and frequency. Following the Toronto Wind Comfort Critera (see Figure 5), the pedestrian level comfort from wind is assessed at a 1.5 m height from the ground per season.

Winter

- There are large parts of the site in which people are comfortable standing (light blue).
- Some areas are suitable for sitting activies (dark blue), especially in the areas with more building density to block winds.
- At the intersections of the train tracks and Lawrence Ave W, there are higher winds and is only comfortable for people walking. There are a few isolated regions near the north of the site by John St where winds are too high and uncomfortable.

Spring

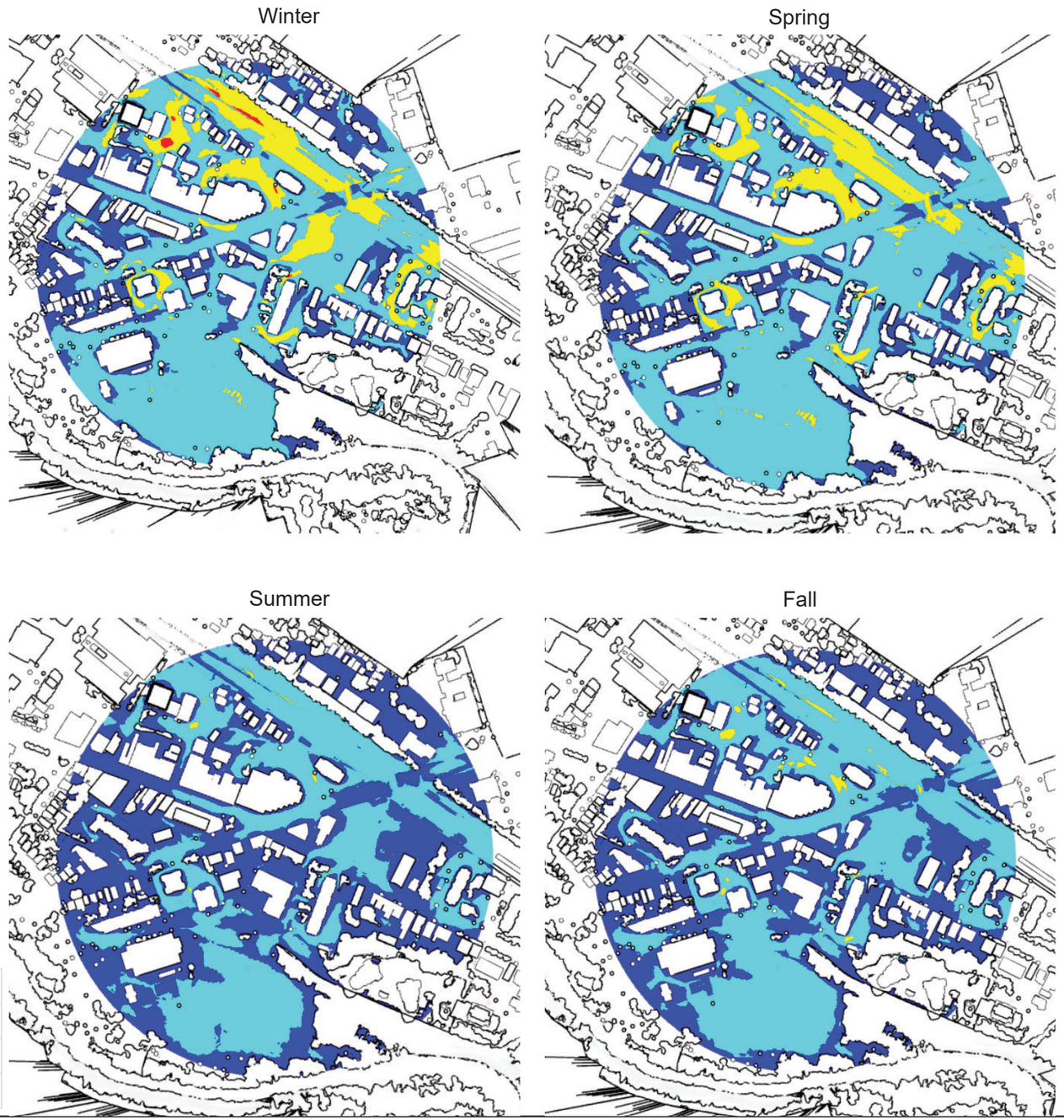
- Similar comfort levels and locations as winter without the very high uncomfortable regions.

Summer and Fall

- There are large parts of the site in which people are comfortable standing and sitting. Areas between Weston Rd and the park especially are comfortable for sitting.

A	10 km/h	< 20%	Sitting
B	15 km/h	< 20%	Standing
C	20 km/h	< 20%	Walking
D	20 km/h	>= 20%	Uncomfortable

Pedestrian Wind Comfort



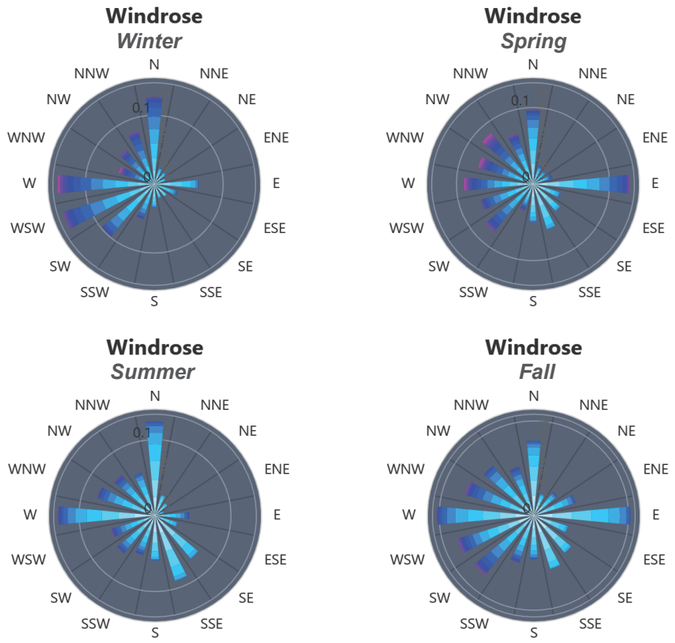


Figure 4: Seasonal Wind Rose
06:00 - 23:00

Comfort Category	GEM Speed [km/h]	Minimum Occurence [% of time]	Description	Area of Application
Sitting	≤10	80	Light breezes desired for outdoor seating areas where one can read a paper without having it blown away.	Park benches, restaurant and cafe seating, balconies, amenity terraces, children's areas, etc. intended for relaxed, and usually seated activities.
Standing	≤15	80	Gentle breezes suitable for passive pedestrian activities where a breeze may be tolerated.	Areas where seated activities are not expected but would be used for passive activities such as bus stops, dog areas, and main entrances.
Walking	≤20	80	Relatively high speeds that can be tolerated during intentional walking, running, and other active movements.	Sidewalks, parking lots, laneways and areas where pedestrian activity is primarily for walking.
Uncomfortable	> 20	20	Strong winds, considered a nuisance for most activities.	Not acceptable in areas with pedestrian access.

Figure 5: City of Toronto Pedestrian Wind Comfort Criteria

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newyork@transsolar.com
220 E 23rd St. Suite 403
New York, NY 10010
KP VZ
+1 212 219 2255

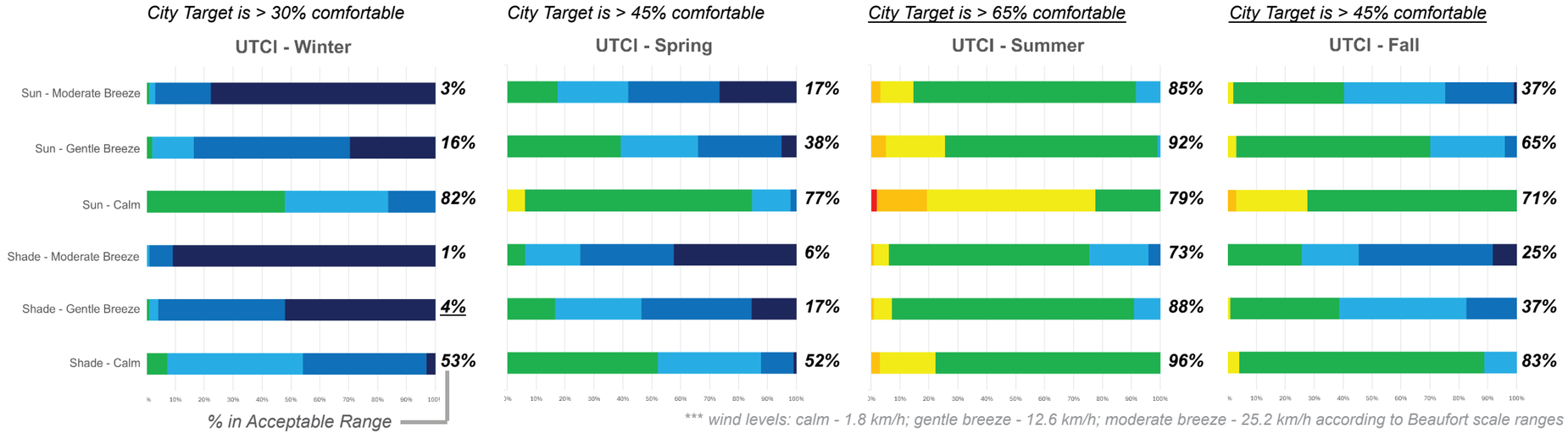
Thermal Comfort: UTCI

High levels of comfort outdoors can be achieved leveraging solar access or shade/shadows and wind conditions. By varying levels of sun and wind on site, different comfort levels can be achieved and for differing activities. Wind is a big driver of comfort in this climate.

- Very Strong Heat Stress (38°+)
- Strong Heat Stress (32-38°)
- Moderate Heat Stress (26°-32°)
- No Thermal Stress (9°-26°)
- Slight Cold Stress (0°-9°)
- Moderate Cold Stress (-13°-9°)
- Strong Cold Stress (<-13°)

Year Period	Time Period	Acceptable UTCI Range
Winter: Nov-Feb	08:00-17:00	0°≤ UTCI ≤ 26°
Spring: Mar-May	08:00-20:00	9°≤ UTCI ≤ 26°
Summer: Jun-Aug	06:00-21:00	9°≤ UTCI ≤ 32°
Fall: Sep-Oct	08:00-20:00	9°≤ UTCI ≤ 26°

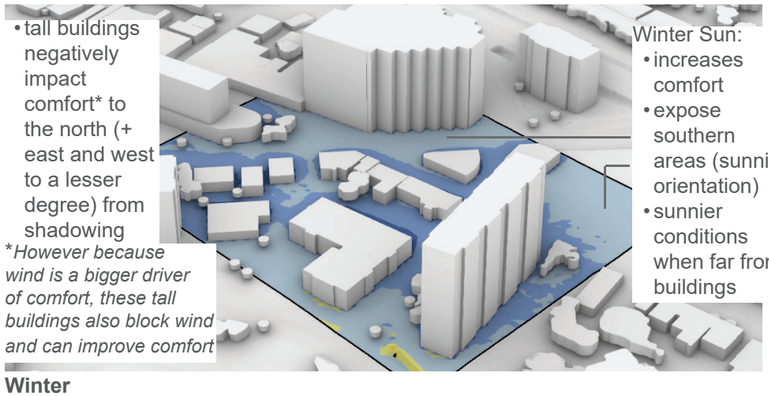
Figure 6: City of Toronto Thermal Comfort Criteria



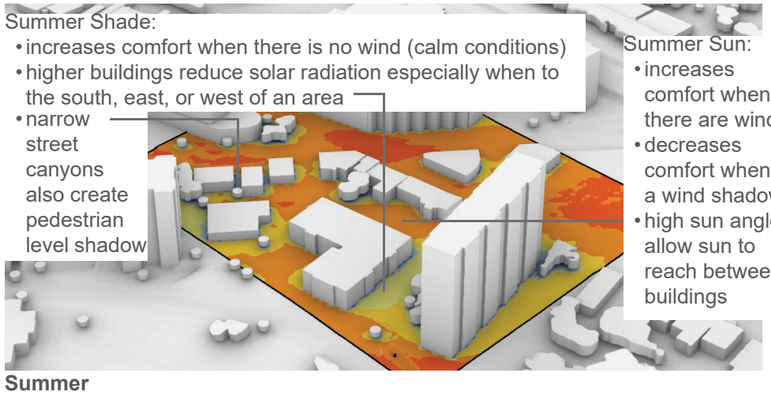
*** wind levels: calm - 1.8 km/h; gentle breeze - 12.6 km/h; moderate breeze - 25.2 km/h according to Beaufort scale ranges

Solar Impact: Radiation

Buildings impact the amount of sun on site. In this radiation study on a sector of the site, building height, orientation, and density affect the amount of sun or shadow/shade received at the pedestrian level affecting thermal comfort.

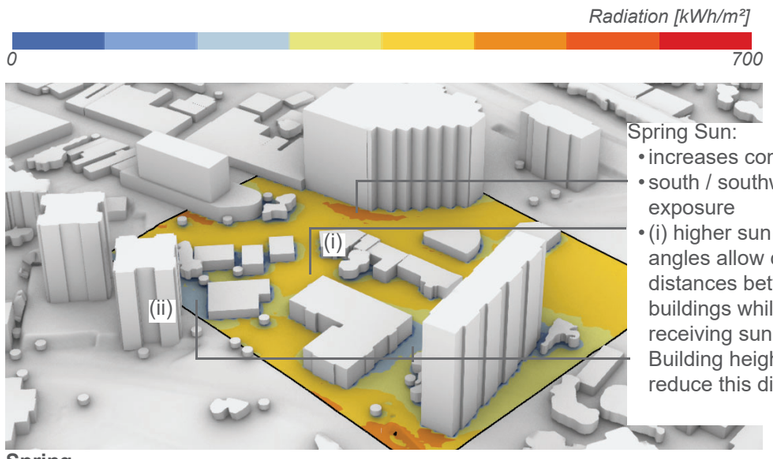


Winter



Summer

Tree shading impacts on all seasons. See section 2.5 for more details on the tree model.

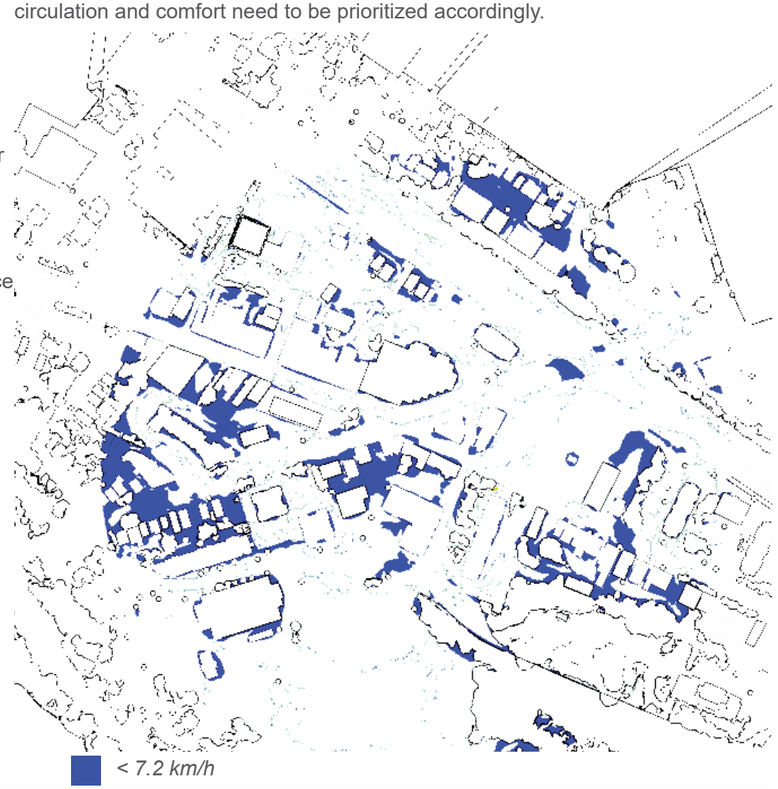


Spring

Fall

Air Circulation Impact: Low Winds

The following map shows locations on site where there are generally low winds (< 7.2 km/h). Lower winds often are beneficial and comfortable areas on site as it increases thermal comfort. However, air stagnation reduces air circulation. At least a minimal light air (> 1.8 km/h) is recommended for good air circulation. Air circulation and comfort need to be prioritized accordingly.



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newyork@transsolar.com
220 E 23rd St. Suite 403
New York, NY 10010
KP VZ
+1 212 219 2255

Existing Outdoor Comfort Conditions – Weston Site (Section II)

Urban Comfort Mapping - Universal Thermal Comfort Indices (UTCI)

This summary presents an overview of current thermal comfort conditions at the Weston site, mapping the thermal comfort using the Universal Thermal Comfort Index (UTCI), which consolidates multiple comfort drivers into a single value for each 10 m grid of the site.

These maps provide pedestrian-level (1.5 m from ground for an average standing height of a person) comfort resolutions for specific site locations using future 2050 weather and integrate all four parameters (air temperature, wind speed, relative humidity, and mean radiant temperature) into a single comfort index.

Factors considered in UTCI evaluation:

- **Air Temperature:** The dry bulb air temperature for the site using weather station data morphed for future 2050 conditions under City of Toronto specified SSP5-8.5 scenario.
- **Relative Humidity:** The relative humidity for the site using weather station data morphed for future 2050 conditions under City of Toronto specified SSP5-8.5 scenario.
- **Wind:** Computational fluid dynamics (CFD) simulations were conducted for 16 wind directions to understand seasonal patterns and magnitudes affecting pedestrian comfort. Wind data using historical wind as per City of Toronto wind modeling guidelines.
- **Mean Radiant Temperature:**
    - *Solar Radiation:* The solar radiation specific to the site is included through the impact of direct and diffuse radiation on the person and the reflectance of the surrounding context.
    - The radiation onto the person from the surrounding ground is also included.
    - *Tree Shading:* The shading and reflectivity effect of the existing trees is included and impacts all seasons.
- **Person Parameters:** The UTCI model compares actual outdoor conditions to a reference environment where a standard person is walking (2.3 METs, or metabolic rate) with a standardized level of clothing insulation appropriate for each season.

Key Findings

- The summer period is largely comfortable over the entire site. Key areas that do not meet the comfort % target are demarcated with gray dots in the seasonal thermal comfort maps. The areas where comfort could be improved include area in between building blocks and fully exposed areas.
- Winter and fall also have large areas of the site that meet the comfort % target.
    - For both seasons, these greater comfort areas are in narrow street canyons and in between dense green areas. Comfort could be improved in large exposed areas and along Lawrence Ave W and Weston. Rd
- Spring has less comfortable areas over the site that meet the comfort % target. The area north of South Station St is more comfortable. Comfort can be improved the greatest during this season.
- Spring conditions in Weston, Toronto still remains cold in the March to May period evaluated.
- Winter, spring, and fall show potential to improve comfort throughout the site because the distribution of UTCI values show many areas only moderately short of the comfort targets. This suggests that passive measures have high potential for improving conditions past the target threshold.

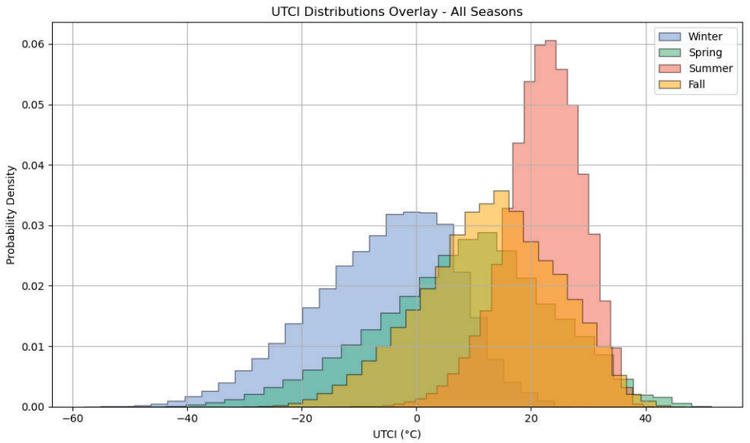


Figure 1: Distribution of Seasonal UTCI [top left]

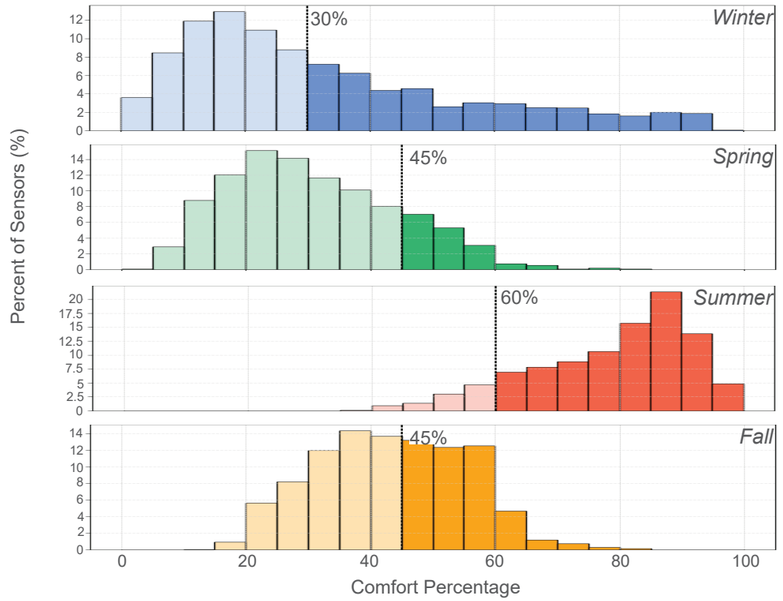
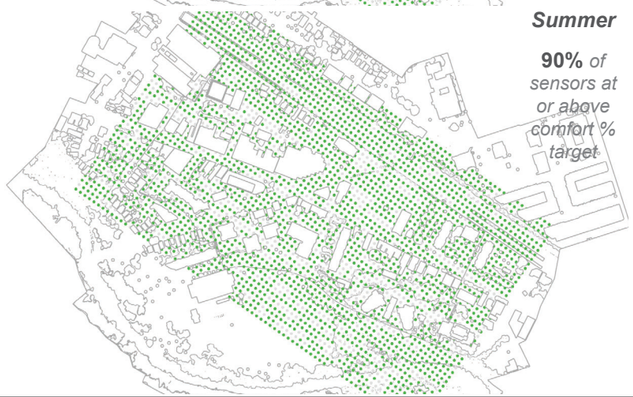


Figure 2: Distribution of Seasonal Comfort Percentages [top right]

Comfort Percentage Maps



= meets comfort percentage target

= does ***not*** meet comfort percentage target

Year Period	Time Period	Acceptable UTCI Range
Winter: Nov-Feb	08:00-17:00	0°≤ UTCI ≤ 26°
Spring: Mar-May	08:00-20:00	9°≤ UTCI ≤ 26°
Summer: Jun-Aug	06:00-21:00	9°≤ UTCI ≤ 32°
Fall: Sep-Oct	08:00-20:00	9°≤ UTCI ≤ 26°

Year Period	Comfort % Target
Winter	30%
Spring	45%
Summer	60%
Fall	45%

Figure 3: City of Toronto Thermal Comfort Criteria

newyork@transsolar.com
220 E 23rd St. Suite 403
New York, NY 10010
KP VZ
+1 212 219 2255

Existing Outdoor Comfort Conditions – Weston Site (Section II)

Urban Comfort Mapping - Universal Thermal Comfort Indices (UTCI)

To assess the comfort on site per season, a typical day and hour was used to provide a point-in-time of the UTCI.

Winter (Solstice Noon Case)
- A substantial portion of the site is within the comfort target. These comfortable locations are all in slight cold stress UTCI, which is acceptable in winter. There are no points that are in the upper range of the comfort range in which the UTCI results in no thermal stress.
- The comfortable regions on site could be expanded as there are often “moderate cold stress” areas adjacent to the ones in acceptable slight cold stress. There is potential for passive techniques to improve these areas to the comfortable range. (See circled examples.)

Spring (Equinox Noon Case)
- Spring is the worst performing season. Weston’s climate is cold in the early spring months and mostly unable to reach the target comfort range for spring. There are more areas in slight cold stress; the site provides winter comfort conditions.
- There are some targeted areas that could be focused on to improve comfort where use is most desired/ applicable. See circled examples for some suitable locations.

Summer (Solstice Noon)
- Summer is almost all comfortable over the site.
- There are some areas that have heat stress and could be focused on to be mitigated. (See circled).

Fall (Equinox Noon)
- Large parts of the site are comfortable. Pink circled areas show examples of key locations that could be expanded to include a greater area that can be comfortable through design interventions.
- Western parts of the site have areas that have very strong heat stress and could be mitigated through design strategies. (See red circles.)

Thermal Comfort Map for Typical Day in Each Season - UTCI

= Extreme Cold Stress (UTCI < -40)
= Very Strong Cold Stress (-40 < UTCI < -27)
= Strong Cold Stress (-27 < UTCI < -13)
= Moderate Cold Stress (-13 < UTCI < 0)
= Slight Cold Stress (0 < UTCI < 9)
= No Thermal Stress (9 < UTCI < 26)
= Moderate Heat Stress (26 < UTCI < 32)
= Strong Heat Stress (32 < UTCI < 38)
= Very Strong Heat Stress (38 < UTCI < 46)
= Extreme Heat Stress (UTCI > 46)

newyork@transsolar.com
220 E 23rd St. Suite 403
New York, NY 10010
KP VZ
+1 212 219 2255

Existing Outdoor Comfort Conditions – Weston Site (Section II)

Urban Comfort Mapping - Universal Thermal Comfort Indices (UTCI)

The following maps show the **direct** solar radiation seasonally. This is the largest contributing factor to thermal comfort through sun access/radiation. It shows the 50th percentile (median) radiation during the season to assess a representative case.

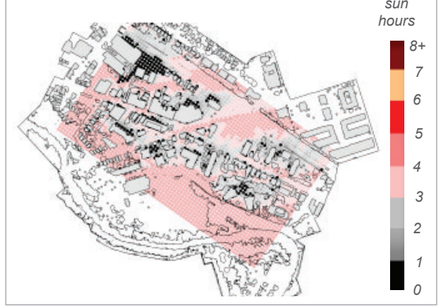
Winter
- There are low sun conditions.
- The highest sun exposure is on the NW corner of the site, resulting in greater comfort there given other climatic factors (such as wind) is controlled.

Spring
- Most of the high sun exposure areas are in the outer surroundings (Raymore Park, Weston Lions Park). The rest of the site has low-moderate sun conditions.
- Improving solar access in the spring will help increase thermal comfort levels.

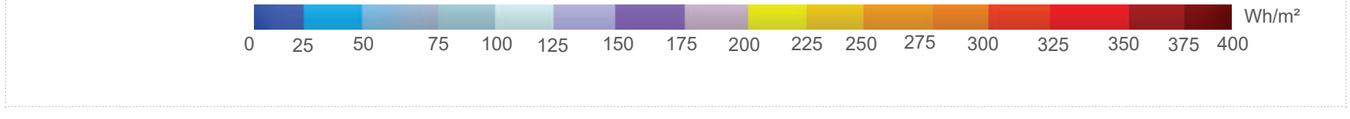
Summer
- High solar exposure throughout the site, but also shadowed areas in between the buildings and well shaded areas along the treelines.

Fall
- Moderate solar exposure throughout the outer surroundings and the main streets.
- Good shading between the buildings from building shadows and tree shading reduce heat stress and offer more comfortable conditions.

March 21: Sun Hour Reference

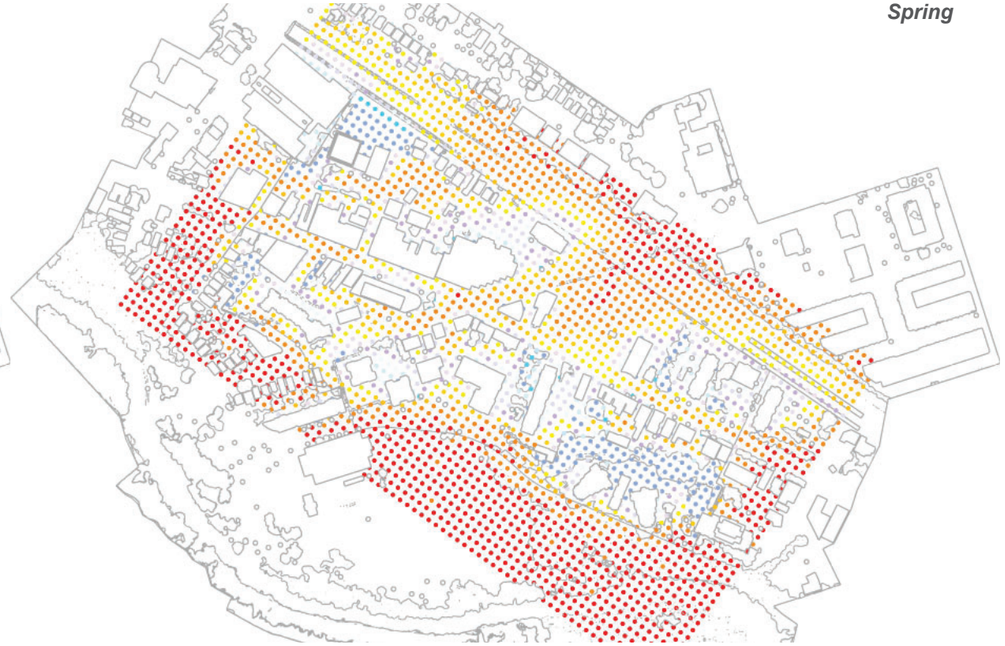


50th Percentile Direct Solar Radiation Per Season



Winter

Spring



Summer

Fall

newyork@transsolar.com
220 E 23rd St. Suite 403
New York, NY 10010
KP VZ
+1 212 219 2255

Existing Outdoor Comfort Conditions – Weston Site (Section II)

Urban Comfort Mapping - Universal Thermal Comfort Indices (UTCI)

The pedestrian wind comfort is assessed cumulating the 16 wind directions from historical weather file data for velocity, direction, and frequency. The 50th percentile (median) wind speeds are shown in the following maps per season to assess typical conditions.

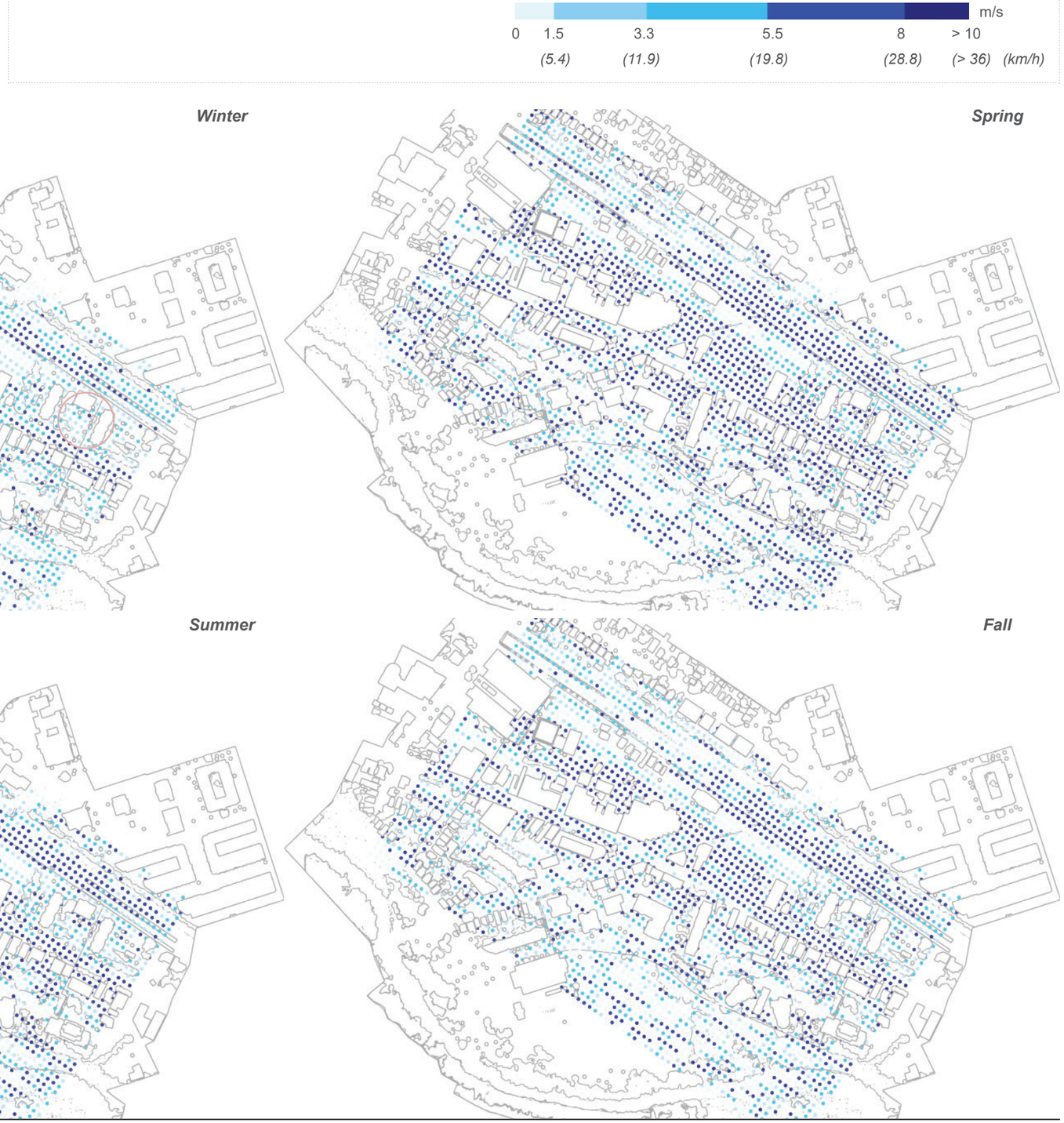
Winter
- There are high wind conditions throughout the site. The highest winds are mainly along the railroad, Weston Rd, and in between the buildings near John St (circled).
- There are also pockets of wind protected areas which offer more comfortable winter conditions (see pink circles).
- Trees and building massing in the development are opportunities to mitigate high wind conditions.

Spring
- Spring has cold temperatures and high wind speeds.
- There are high wind conditions through the site. Using design strategies to reduce winds will be able to improve spring outdoor comfort.

Summer
- There is a mix of wind conditions throughout the site. As summer is largely comfortable, this is not the limiting design case.
- However, ensuring some breezes through the site will reduce heat stress conditions.

Fall
- Wind conditions are similar to summer.
- Maintaining gentle and moderate breezes at higher direct sun exposed areas will reduce heat stress.
- As Weston is a largely cold climate, it may be preferred to extend the summer season into fall and keep moderate heat stress conditions for those who prefer it. It can also help activate the area and encourage prolonged outdoor use.

50th Percentile Wind Velocity Per Season



Existing Outdoor Comfort Conditions – Weston Site

Urban Comfort Mapping - Universal Thermal Comfort Indices (UTCI)

Simulation Details

- 16 wind direction computational fluid dynamic (CFD) simulation
- Incompressible LBM (lattice Boltzmann method) with 3 fluid passes
- Turbulence Model: k-omega SST DDES
- Software: SimScale (OpenFOAM® solver)
- Mesh y+ value: < 2000 in area of interest (stable)
- Modeled radius: 300 m region of interest with additional 50m+ of surrounding context region
- Wind Source: CAN_ON_Toronto-Pearson.Intl.AP.716240_TMYx
    - 65 year wind data: 1950-2023
- Includes terrain, existing buildings, existing landscape
- Pedestrian Wind Comfort assessed at 1.5 meters
- Wind safety criteria based on City of Toronto criteria (see Figure 3)
    - Evaluated for whole year, 00:00 - 00:00
- Wind comfort criteria based on City of Toronto criteria (see Figure 5)
    - Evaluated from 06:00 - 23:00
    - Evalued Seasonally:
        Winter: December - February
        Spring: March - May
        Summer: June - August
        Fall: September - November

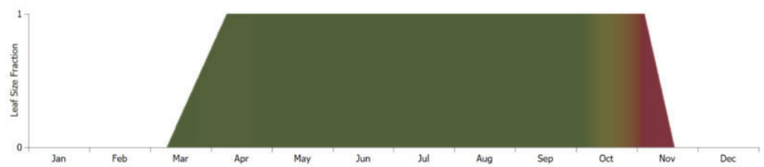
Universal Thermal Comfort Index (UTCI)

The Universal Thermal Comfort Index (UTCI) accounts for air temperature, wind velocity, relative humidity, and the mean radiant temperature (effects from solar radiation) to assess human comfort given site and climate conditions independent of a person's specific demographics.

- Assessment of high-level thermal comfort based on City of Toronto criteria (see Figure 6) with UTCI comfort metric for Section I
    - Wind level simulated using Beaufort scale ranges
        Calm: 1.8 km/h
        Gentle Breeze:12.6 km/h
        Moderate Breeze: 25.2 km/h
    - Sun simulated: +20K mean radiant temperature
    - Shade simulated: +0K mean radiant temperature

- Assessment of detailed thermal comfort for Section II based on 2050 future SSP5-8.5 morphed weather file from the City of Toronto using Pearson International Airport weather station and a CWEC 2020 weather file.
    - Evapotranspiration and thermal mass effects are not included in UTCI model
    - Concrete ground assumed and included in the mean radiant temperature calculation.
    - Solar radiation conditions simulated on hourly basis
    - Tree species modeled with maple trees *(Acer Platanoides)* to simulate seasonal dynamic leaf conditions.
        Leaf growth period: March 11 - April 10
        Leaf shrinkage period: November 5-20
        Leaves bare between November 20 - March 11

Acer Platanoides Dynamic Leaf Conditions



Acer Platanoides

VLR (summer)	10.3 %
VLR (fall)	8.6 %

LengthOfDay Schedule

Leaf Growth	Mar 11 - Apr 10
Spring Color Change	Mar 25 - Apr 24
Fall Color Change	Oct 6 - Nov 5
Leaf Shrinkage	Nov 5 - Nov 20

Note: The effect of leaf shading is present for all seasons. The winter analysis period, as per the City of Toronto guidelines, is Nov - February such that the early winter still has some shading from tree canopies.

newyork@transsolar.com
220 E 23rd St. Suite 403
New York, NY 10010
KP VZ
+1 212 219 2255

Appendix: Existing Thermal Comfort Conditions – Weston Site

Comfort Percentage Map

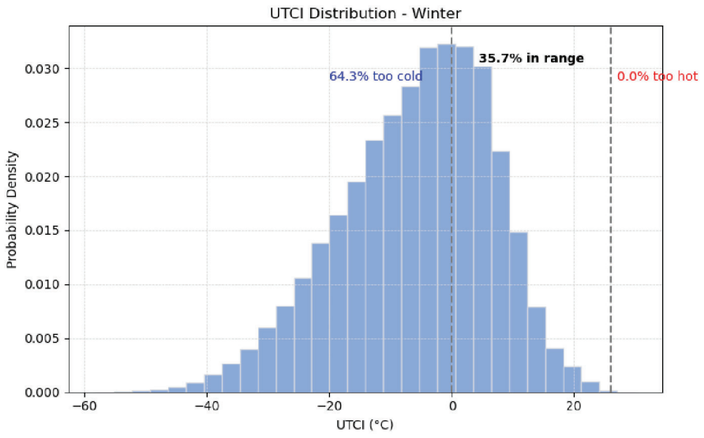
Winter

Year Period	Time Period	Acceptable UTCI Range	Comfort % Target
Winter: Nov-Feb	08:00-17:00	0°≤ UTCI ≤ 26°	30%

● = meets comfort percentage target

● = does ***not*** meet comfort percentage target

43% (1,283 out of 2,963) sensors are at or above comfortable percentage target



Appendix: Existing Thermal Comfort Conditions – Weston Site

Comfort Percentage Map

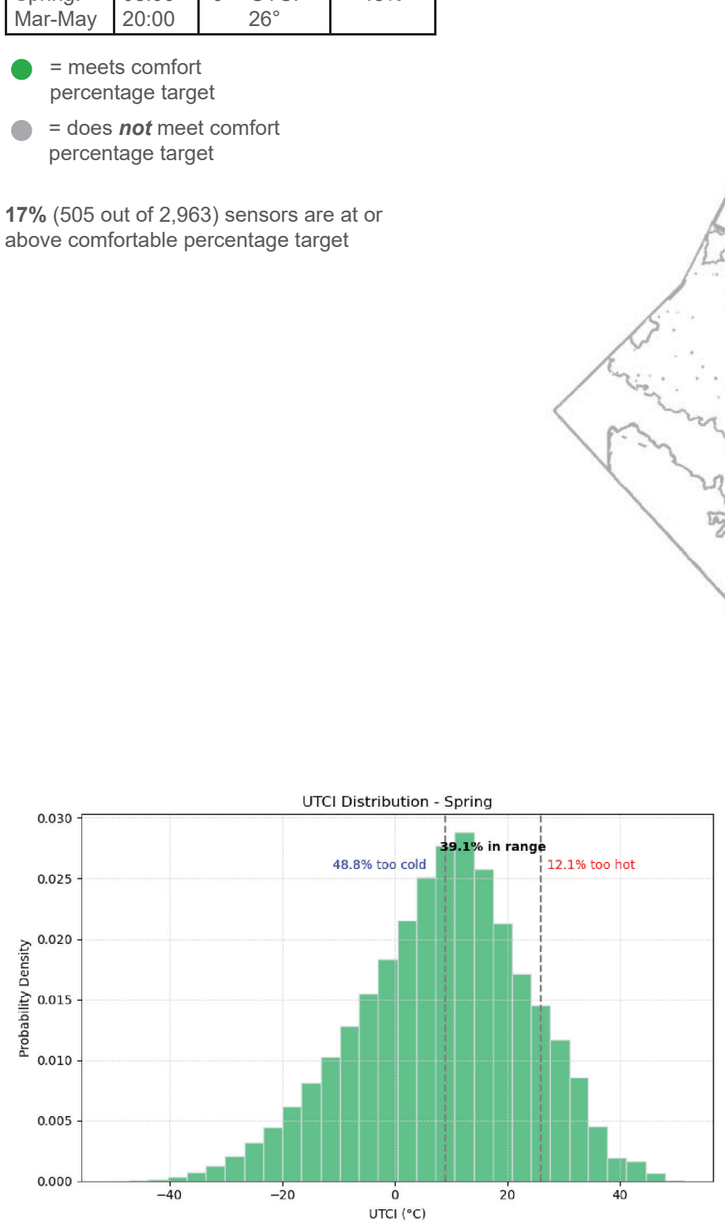
Spring

Year Period	Time Period	Acceptable UTCI Range	Comfort % Target
Spring: Mar-May	08:00-20:00	9°≤ UTCI ≤ 26°	45%

● = meets comfort percentage target

● = does ***not*** meet comfort percentage target

17% (505 out of 2,963) sensors are at or above comfortable percentage target



Appendix: Existing Thermal Comfort Conditions – Weston Site

Comfort Percentage Map

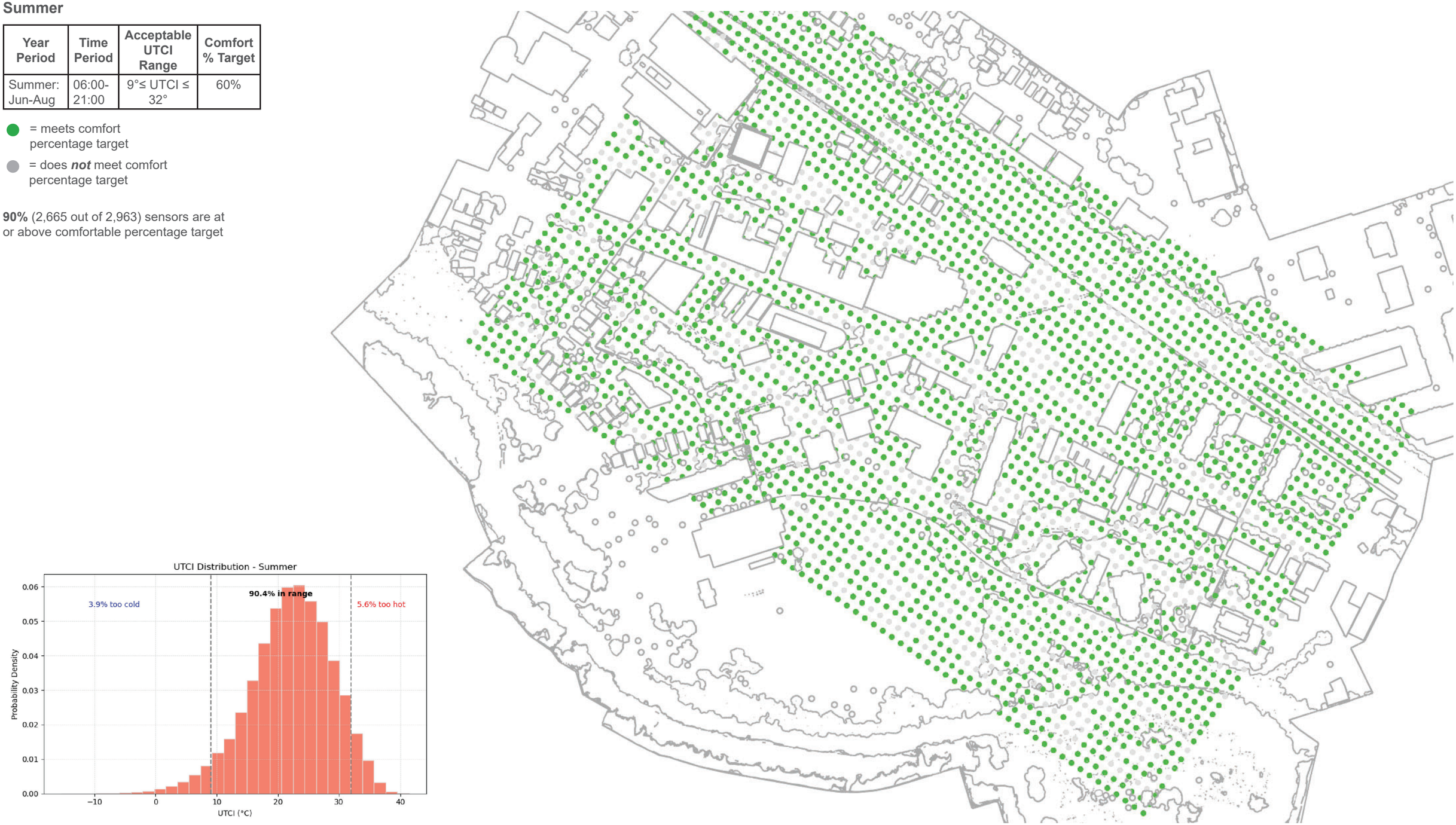
Summer

Year Period	Time Period	Acceptable UTCI Range	Comfort % Target
Summer: Jun-Aug	06:00-21:00	9°≤ UTCI ≤ 32°	60%

● = meets comfort percentage target

● = does ***not*** meet comfort percentage target

90% (2,665 out of 2,963) sensors are at or above comfortable percentage target



Appendix: Existing Thermal Comfort Conditions – Weston Site

Comfort Percentage Map

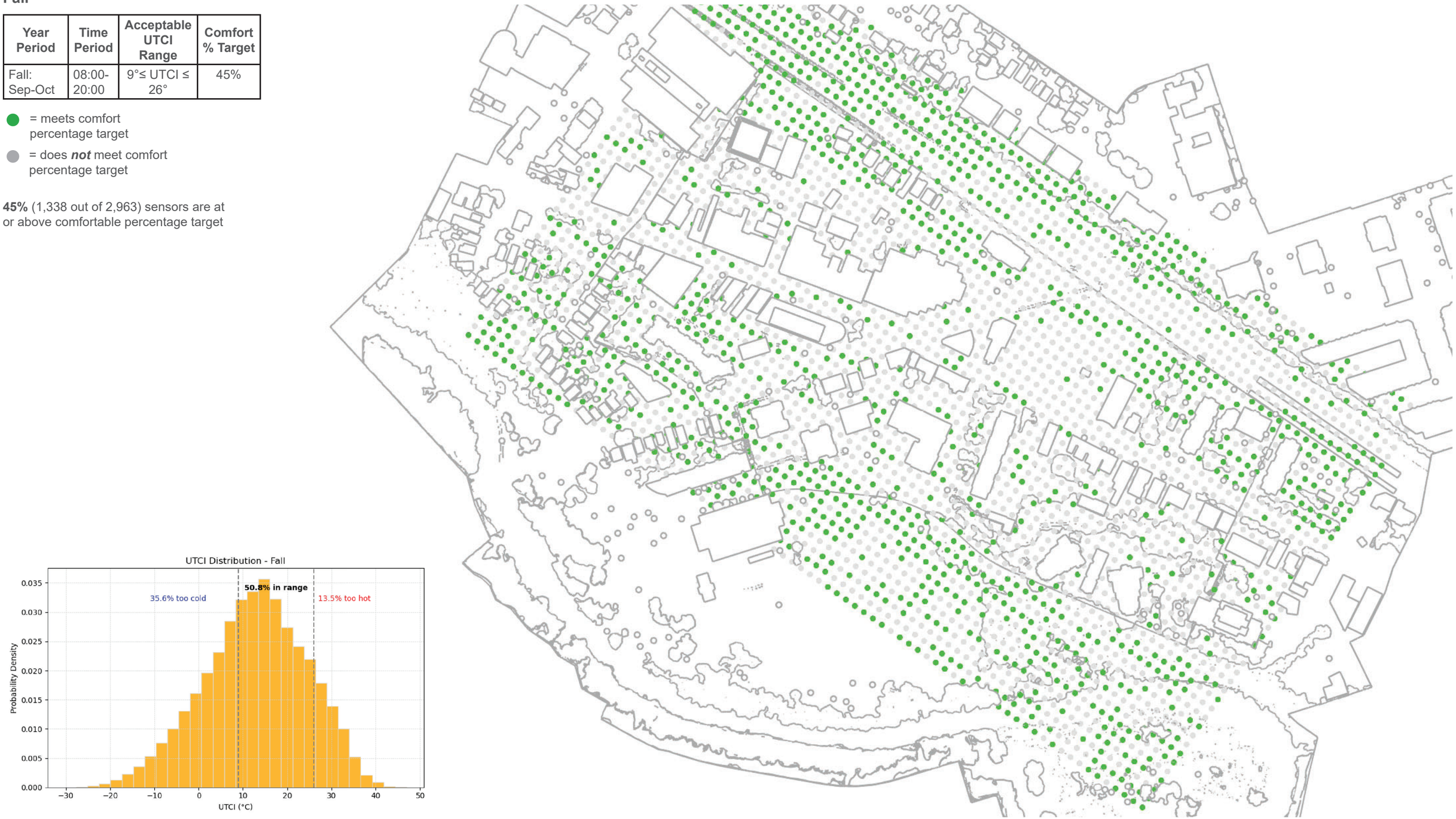
Fall

Year Period	Time Period	Acceptable UTCI Range	Comfort % Target
Fall: Sep-Oct	08:00-20:00	9°≤ UTCI ≤ 26°	45%

● = meets comfort percentage target

● = does ***not*** meet comfort percentage target

45% (1,338 out of 2,963) sensors are at or above comfortable percentage target



newyork@transsolar.com
220 E 23rd St. Suite 403
New York, NY 10010
KP VZ
+1 212 219 2255

Appendix: Existing Thermal Comfort Conditions – Weston Site

Comfort Percentage Map (10% Intervals)

Year Period	Time Period	Acceptable UTCI Range	Comfort % Target
Winter: Nov-Feb	08:00-17:00	0°≤ UTCI ≤ 26°	30%

- Locations 10% too low of the comfort target (orange) are areas with high comfort improvement with design interventions, especially with passive means. These are recommended to be focus areas during development of the site.

Thermal Comfort Map

Winter

Appendix: Existing Thermal Comfort Conditions – Weston Site

Comfort Percentage Map (10% Intervals)

Year Period	Time Period	Acceptable UTCI Range	Comfort % Target
Spring: Mar-May	08:00-20:00	9°≤ UTCI ≤ 26°	45%

- Locations 10% too low of the comfort target (yellow, light orange) are areas with high comfort improvement with design interventions, especially with passive means. These are recommended to be focus areas during development of the site.

Thermal Comfort Map

Spring

Appendix: Existing Thermal Comfort Conditions – Weston Site

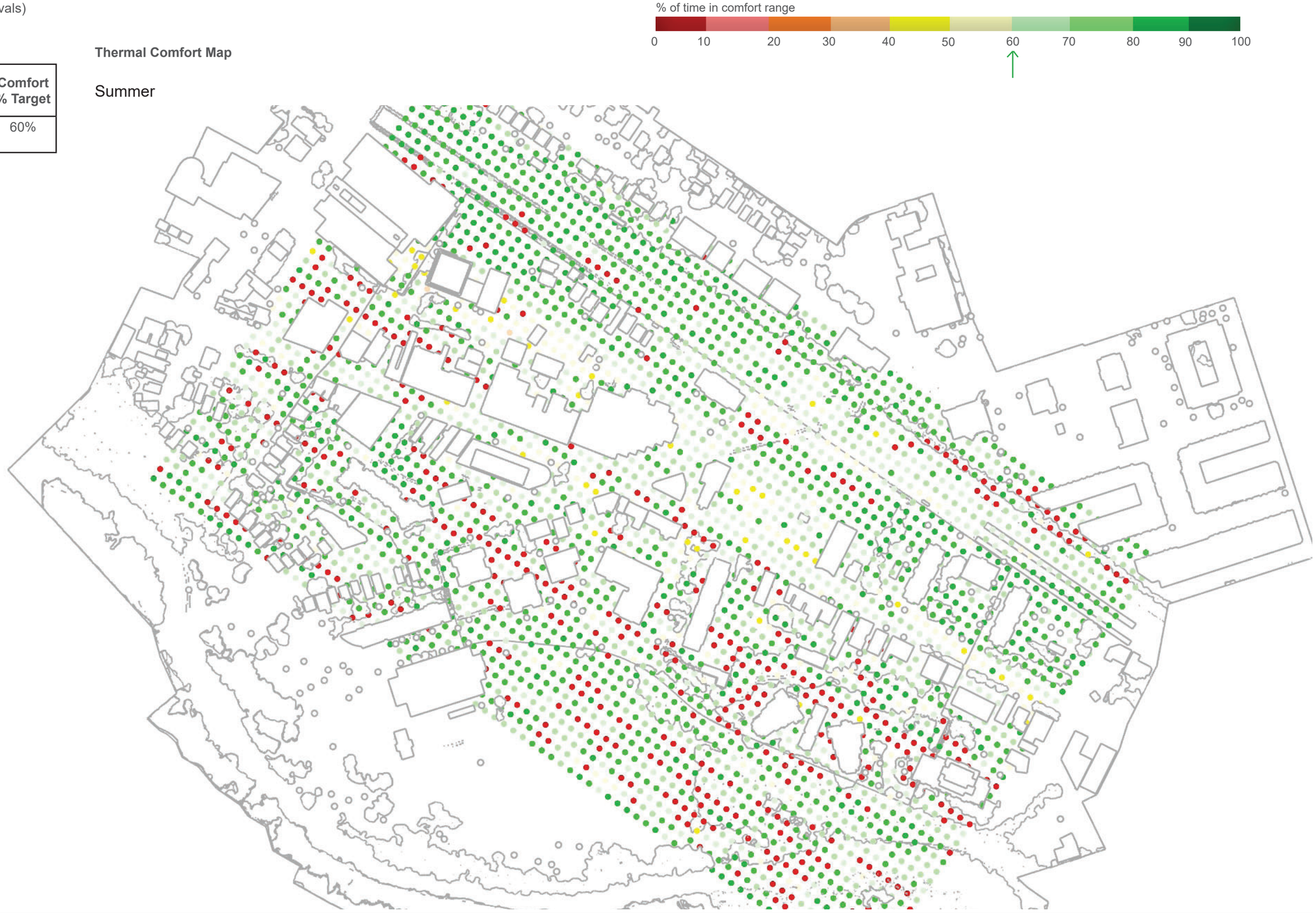
Comfort Percentage Map (10% Intervals)

Year Period	Time Period	Acceptable UTCI Range	Comfort % Target
Summer: Jun-Aug	06:00-21:00	9°≤ UTCI ≤ 32°	60%

- Locations 10-20% too low of the comfort target (pale yellow, yellow) are areas with high comfort improvement with design interventions, especially with passive means. These are recommended to be focus areas during development of the site.

Thermal Comfort Map

Summer



Appendix: Existing Thermal Comfort Conditions – Weston Site

Comfort Percentage Map (10% Intervals)

Year Period	Time Period	Acceptable UTCI Range	Comfort % Target
Fall: Sep-Oct	08:00-20:00	9°≤ UTCI ≤ 26°	45%

- Locations 10% too low of the comfort target (yellow, light orange) are areas with high comfort improvement with design interventions, especially with passive means. These are recommended to be focus areas during development of the site.

Thermal Comfort Map

Fall